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COCHRANE UPDATED REVIEW

Endovascular Ruptured Abdominal Aortic Aneurysm Repair (EVRAR): A Systematic Review☆

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Background. *To review evidence supporting the use of endovascular ruptured aneurysm repair (EVRAR) for treatment of ruptured abdominal aortic aneurysm (RAAA).*
Methods. *A systematic review of the medical literature was performed for relevant studies. We searched a number of electronic databases and hand-searched relevant journals until November 2006 to identify studies for inclusion. We considered studies in which patients with a confirmed ruptured abdominal aortic aneurysm were treated with EVRAR, which reported endpoints of mortality and major complications.*
Results. *There was 1 randomised controlled trial (RCT), 33 non-randomised case series (24 retrospective and 9 prospective) reports were identified comparing EVRAR (*n = *891) with conventional open surgical repair for the treatment of RAAA. Whilst no benefit in the primary outcome of mortality was noted in the only RCT, evidence from non-randomised studies suggest that EVRAR is feasible in selected patients, where it may be associated with a trend towards reductions in blood loss, duration of intensive care treatment, early complications, and mortality.*
Conclusions. *For the treatment of symptomatic or ruptured abdominal aortic aneurysm, emergency endovascular repair (EVRAR) is feasible in selected patients, with early outcomes comparable to best conventional open surgical repair for the treatment of RAAA.*

Keywords: Abdominal aortic aneurysm; Rupture; Surgical treatment; Endovascular aneurysm repair (EVAR); Endovascular ruptured aneurysm repair (EVRAR); Systematic review.

Introduction

Abdominal aortic aneurysm (AAA), affects between 1.2% and 7.6% of the population over 50 years of age in the United Kingdom.[1,2] Untreated, progressive aneurysm enlargement can lead to rupture, which is lethal in 80% of those affected and responsible for over 6800 deaths per annum in the United Kingdom and 2.1% of all deaths in men over 65 years.[2,3] Excellent results can now be achieved with elective open repair, with some specialist centres reporting mortality rates of less than 2% and surgeons in non-specialist units achieving mortality rates of 5% to 8%.[4–7] This contrasts with emergency open repair for a ruptured AAA (RAAA), in these critically ill patients, which carries a mortality rate of 30% to 65%.[4,8,9] In the last two decades a new minimally-invasive technique, endovascular aneurysm repair (EVAR), has offered an alternative therapy to conventional open repair for selected patients with AAA, and has shown significant reductions in early complications and mortality.[10,11] Furthermore, several studies have shown that EVAR, especially under local anaesthesia, reduces the physiological insult to the body as compared to conventional open surgical repair.[12,13] This has led some to consider emergency endovascular aneurysm repair (EVRAR) as an alternative to conventional open repair in selected patients with RAAA.[13–15]

This article reviews the available published evidence to support the use of emergency endovascular aneurysm repair (EVRAR) as compared to conventional open repair (OR) of RAAA, for patients with RAAA.

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Methods

Criteria for considering studies

Our objective was to review the published evidence to allow assessment of the advantages and disadvantages of EVAR for patients with RAAA (EVRAR). This was determined by the effect on short-term mortality, major complication rates, aneurysm exclusion, and late complications when compared with patients who have had conventional open repair of RAAA. To ensure comparability of participants were considered for inclusion. There must have been evidence of rupture on imaging, computerised tomography angiography (CTA) or magnetic resonance angiography (MRA), or objective acute symptoms suggestive of impending rupture of a known aneurysm (abdominal or back pain in a patient with an aneurysm) to warrant inclusion. Studies where objective evidence of RAAA is not clear were excluded.

We did not limit our search in respect to the type of endovascular intervention or device type.

The following outcome measures were considered: (1) mortality (30 day, or in-hospital mortality, i.e. procedure related); (2) aneurysm exclusion (no flow in the AAA sac, or further extravasation (escape of blood from the vessel into the tissues) beyond the sac on follow-up imaging 30 days after the procedure); (3) comparative surrogate measures of procedural success (blood loss, procedural time, ICU stay). Data was sought for other important outcome measures, such as: major complications (i.e. open conversion, haemorrhage, myocardial infarction, stroke, renal failure, respiratory failure, pneumonia, bowel ischaemia, lower limb ischaemia); minor complications (i.e. haematoma, wound infection); long term complications, re-intervention rates and mortality. However, these data were inconsistently reported and as such comments were possible pertain to individual studies.

Search strategy

We searched for articles using the broad terms ''endovascular'' AND ''abdominal aortic aneurysm'' AND ''ruptured'' in all databases. The last search prior to preparation of this review was performed in November 2006. We searched the Cochrane Peripheral Vascular Diseases Group trials register (last searched October 2006) and the Cochrane Central Register of Controlled Trials (CENTRAL) database (last searched Issue 4, 2006) for trials describing endovascular repair of ruptured or symptomatic abdominal aortic aneurysm. We performed electronic searches of the following bibliographic databases: (1) AMED (Allied and Complementary Medicine Database); (2) Best Evidence; (3) Biological Abstracts (4) HMIC (Health Management of Information Consortium − comprising DH-data, the King's Fund Database and Helmis); (5) NHS DARE (Database of Assessments of Reviews of Effects); (6) NHS EED (Economics Evaluations Database); (7) NHS HTA (Health Technology Assessment); (8) PubMed; (9) Science Citation Index; (10) MEDLINE. In order to collect any articles missed by searches we also hand-searched relevant journals, retrieved articles, and relevant. Searches were not restricted by publication type, study design or language of publication.

Selection

Authors, M.D. and D.W.H., evaluated the trials under consideration independently for appropriateness for inclusion and for methodological quality. Disagreements were resolved on discussion with the review team and agreed arbitrators. The searches identified 41 potentially relevant articles comparing EVRAR with conventional open surgical repair for the treatment of RAAA to which exclusion criteria were applied: 1 randomised controlled trial; 33 case series (24 retrospective and 9 prospective); 7 case reports.

Only 1 RCT was identified, and as such no tests of heterogeneity or sensitivity analysis were performed, and meta-analysis was not indicated.

Results

There was only 1 completed randomised controlled trial (RCT)[16] comparing EVRAR with conventional open surgical repair for the treatment of RAAA. Thirty-three case series (24 retrospective and 9 prospective)[13−15,17−46] describing EVRAR (in 876 patients) were identified, Table 1. A number of case-control studies and cohort studies comparing outcomes of EVRAR with open surgical repair (OR) were found,[13,15,17−19,22,24,27,30,31,35,38,41,44−46] these were invariably non-randomised and in some cases the EVRAR had been compared to historical controls. Therefore, the following review has limited high-quality evidence on which to base strong recommendations, but endeavours to present the available evidence as succinctly as possible.

Hinchcliffe *et al.*,[16] in late 2006 reported the results of a pilot study as part of an ongoing randomised controlled trial comparing endovascular (EVRAR) and open surgery (OR) for the treatment of ruptured abdominal aortic aneurysm (RAAA). The trialists

Table 1. Mortality after endovascular ruptured aneurysm repair (EVRAR)

Study	Design	%EVAR Suitable*	EVRAR	OPEN group (if quoted)	*p* value (if quoted)
Hinchcliffe 2006	PRCT	93%	8/15 (53)	9/17 (53%)	NS
Franks 2006	PCS†	100%	1/10 (10)	7/10 (70)	–
Arya 2006	PCCS	42%	4/17 (24)	11/23 (47)	NS
Lagana 2006	CS		4/38 (10.5)		
Visser 2006	RCS	47%	8/26 (31)	9/29 (31)	NS
Alsac 2005	PCS	73%	4/17 (23.5)	10/20 (50)	0.09
Brandt 2005	RCS	72%	0/11 (0)	2/13 (15)	NS
Greco 2005	RCS	–	114/290 (39)	2627/5508 (47)	0.05
Kapma 2005	RCS	36%	5/40 (13)	64/213 (30)	0.02
Larzon 2005	RCS	–	2/15 (13)	12/26 (46)	0.05
Peppelenbosch 2005	RCS		8/35 (23)		–
Vaddineni 2005	RCS	60%	2/9 (22)	4/15 (26)	NS
Castelli 2005	CS		5/25 (20)		
Gerassimidis 2005	CS		9/23 (39)		
Hechelhammer 2005	CS		4/37 (10.4)		
Mehta 2005	CS		7/30 (23)		
Lombardi 2004	CS		0/5 (0)		
Lee 2004	RCS	88%	1/13 (7.7)	1/4 (25)	–
Rubin 2004	CS		1/5 (20)		
Peppelenbosch 2003	PCS†	80%	4/26 (15)	4/14 (28)	–
Reichart 2003	PCS	42%	1/6 (16.6)	4/13 (30)	–
Resch 2003	PCS	79%	4/14 (29)	8/23 (35)	0.05
Scharrer-Pamler 2003	CS		3/24 (12.5)		
Van Herzeele 2003	CS		1/9 (11)		
Verhoeven 2002	PCS	34%	1/9 (11)	7/31 (23)	–
Yilmaz 2002	PCS	81%	4/17 (24)	12/29 (41)	NS
Doss 2002	CS		0/6 (0)		
Lachat 2002	CS		2/21 (9.5)		
Orend 2002	CS		4/21 (19)		
Van Sambeek 2002	CS		6/22 (19)		
Hinchcliffe 2001	CS		9/20 (45)		
Ohki 2000	PCS	80%	2/20 (10)	0/5 (0)	–
Greenberg 2000	CS		0/3 (0)		
Ohki 1999	CS		2/12 (17)		
Overall[13,15,16,18–47]		67% (34–100)	18% (0–53)	34% (0–70)	

Data in parenthesis represents (%) or (range).[13,15,16,18–47] Prospective Randomised Controlled Trial (PRCT); Prospective case-control study (PCCS); Prospective Cohort Study (PCS); Retrospective Cohort Study (RCS); Case series (CS). *Percentage of cohort considered for endovascular repair deemed anatomically suitable after contrast-enhanced CT scan. †Control group historical.

considering 103 patients with suspected ruptured AAA, and randomised 32 patients (15 to EVRAR and 17 to OR). This low rate of patient randomisation (31%) may be in part explained by the broad exclusion criteria applied, including: patient unfit for open repair; death before randomisation; inability to give consent; age; refusal of operation; no team available; surgeon preference. This trial highlights the significant logistical problems related in having a fully trained, equipped, and committed endovascular team available at all times. On an intention to treat basis there was no significant difference in mortality for the EVRAR group, 8 of 15 (53%) compared to OR group, 9 of 17 (53%). If we exclude those patients who died after randomisation but before intervention, mortality for the EVRAR group, 7 of 13 (54%) including 2 EVRAR failures requiring open conversions (1 survivor; 1 non-survivor), compared to OR group, 6 of 14 (43%), non-significant. Of patients who survived intervention, there was no significant difference in postoperative complications (moderate and severe) for the EVRAR group, 77%, compared to OR group, 80%. Severe renal complications were significantly more common in the EVRAR group, 6 of 11 (55%), compared to OR group, 1 of 14 (7%), $p < 0.02$. A significant difference in recorded blood loss and blood transfusion requirements is recorded but difficult to interpret when comparing minimally invasive, in which intra-abdominal blood loss cannot be counted, and open surgical procedures. Whilst the authors should be complemented on their enthusiasm to answer this question, their results must be considered with caution due to logistical deficiencies in the availability of a 24-hour endovascular service at their unit, subjective entry criteria, and failure to recruit sufficient numbers.

The results of non-randomised case series comparing EVRAR, to contemporary or historical series of open repair (OR) for the treatment of RAAA,[13,15,17–19,22,24,27,30,31,35,38,41,44–46] are compared to the 1 available RCT[16] and presented in Tables 1–4.

Table 2. Length of ICU stay

Study	eEVAR group	OPEN group	*p* value (if quoted)
Franks 2006	1.3	6.1	0.01
Alsac 2005	3	13	0.01
Brandt 2005	4.8	8.5	NS
Kapma 2005	0*†	48*†	0.001
Vaddenini 2005	5*	20*	–
Peppelenbosch 2003	46*†	154*†	–
Reichart 2003	2.25	13 days	–
Resch 2003	1*	3*	0.02
van Sambeek 2002	8*†	62*†	0.004
Yilmaz 2002	2.2	5.2	0.05

Data represents mean unless indicated *median. Values in days except were indicated †hours.

Discussion

Abdominal aortic aneurysm

Abdominal aortic aneurysm (AAA), affects between 1.2% and 7.6% of the population over 50 years of age in the United Kingdom. The prevalence of AAA in men is approximately three times greater than in women, and the incidence increases with advancing age.[1,2] The risk of aneurysm rupture has been shown to be proportional to aneurysm size, with aneurysms measuring less than 5.0 cm having an annual rupture rate of approximately 1% whereas those greater than 7.0 cm in diameter have an annual rupture rate of over 30%.[5,47] The UK Small Aneurysm Trial has shown that in general, patients benefit from aneurysm repair when maximum aneurysm diameter exceeds 5.5 cm, at which stage the risk of spontaneous rupture exceeds the risks of conventional open surgical repair.[5] Excellent results can now be achieved with conventional open repair, with some specialist centres reporting mortality rates of less than 2% and surgeons in non-specialist units achieving mortality rates of 5% to 8%.[5,7,48] Furthermore, a newer minimally-invasive technique called endovascular aneurysm repair (EVAR), first reported by Parodi in 1991,[49] now offers an alternative treatment in certain patients. Two recent large prospective randomised controlled trials have compared elective EVAR with conventional open repair for the treatment of large AAA, and have shown significant reductions in early complications and mortality.[11,50] However, these trials have also reinforced the knowledge that open repair is a successful technique and will remain a common form of treatment for over half of those patients presenting for whom EVAR is unsuitable on anatomical grounds or due to other factors.[11,50] It is also clear from these studies that EVAR is associated with a higher re-intervention rate than open repair,[11,50] and registry data would suggest that these re-intervention rates can remain constant and may even increase with time.[51] As such long-term surveillance is essential after EVAR to monitor for endoleaks and stent integrity in order to reduce the small but significant incidence of late aneurysm rupture (Fig. 1).[52]

Table 3. Length of procedure

Study	EVRAR group	OPEN group	*p* value (if quoted)
Hinchcliffe 2006	160	150	0.34
Franks 2006	156	186	0.04
Alsac 2005	156	222	0.1
Brandt 2005	178	207	NS
Kapma 2005	110*	180*	0.001
Vaddenini 2005	143	181	–
Peppelenbosch 2003	154	155	–
Verhoeven 2002	110	122.5	–
van Sambeek 2002	193	203	NS
Yilmaz 2002	173	273	0.05
Ohki 2000	336*	492*	–

Data represents mean unless indicated *median. Values in minutes.

Table 4. Blood loss and transfusion requirement

Study	EVRAR group	OPEN group	*p* value (if quoted)
A: Blood loss			
Hinchcliffe 2006	200	2100	0.004
Kapma 2005	200*	3500	0.001
Vaddenini 2005	475	2880	0.0001
Peppelenbosch 2003	1100	2600	–
Reichart 2003	300	4500	–
Resch 2003	800	4000	0.0001
van Sambeek 2002	125*	3400	0.01
Yilmaz 2002	660	3550	0.05
Ohki 2000	400*	2000	–
B: Transfusion requirements			
Hinchcliffe 2006	3	6	0.02
Franks 2006	0.86†	10.7†	0.01
Alsac 2005	1520	3075	0.1
Brandt 2005	964	1986	0.02
Kapma 2005	0*†	6†	0.001
Vaddenini 2005	3.78†	6.93†	0.014
Reichart 2003	0	1600	–
Resch 2003	2†	9†	0.02
Ohki 2000	3*†	6†	–

A: Data represents mean unless indicated *median. Values in millilitres. B: Data represents mean except were indicated *median. Values in millilitres except were indicated †units.

Ruptured abdominal aortic aneurysm

Currently, rupture leads to death in over 80% of those affected, including 30% to 65% of those who receive conventional open surgical repair, and is responsible for over 6800 deaths per annum in the United Kingdom and 2.1% of all deaths in men over 65 years.[2,4,9] The haemorrhagic shock and lower torso ischaemia-reperfusion injury which accompanies RAAA activate

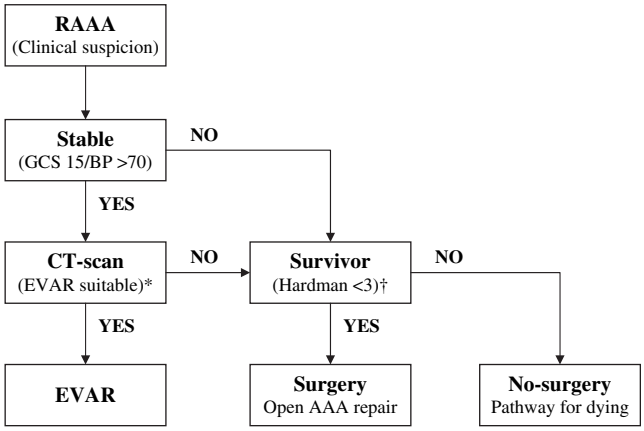

Fig. 1. Algorithm for the treatment of patients presenting with ruptured abdominal aortic aneurysm. *EVAR suitable (see Table 5), †Hardman criteria.[9]

multiple inflammatory pathways in the body inducing a harmful proliferative systemic inflammatory response syndrome characterized by immune cells activation, pro-inflammatory mediator production and widespread vital organ injury (heart, lungs, liver, kidney, gut, etc.). The sequential failure of these organs despite intensive care support, once established leads to death in over 70% of cases.[53–55] Detailed risk analysis and scoring systems have been shown to predict non-survivors in certain groups but individual patient outcomes cannot be accurately predicted.[9,56] Clinicians have been reticent to apply these scoring systems rigidly as to do so would serve to preclude most patients with RAAA from surgical repair, condemning them to certain death.[9] It is also now clear that those patients who undergo successful open repair of RAAA enjoy a post-operative quality of life similar to the ''normal population''.[57]

Endovascular ruptured aneurysm repair (EVRAR)

Since the first description of the EVAR technique,[49] many specialised vascular surgery centres have adopted its use in the elective treatment of abdominal aortic aneurysm, where its use has contributed to a reduction in early postoperative morbidity and mortality.[11] Furthermore, several studies have confirmed that the use of EVAR, especially under local anaesthesia, reduces the physiological insult to the body as compared to conventional open surgical repair.[12,58] These potential benefits have led several experienced units to offer endovascular ruptured aneurysm repair (EVRAR), as an alternative to conventional open surgery, in selected patients.[59,60] These early reports have suggested EVRAR is feasible and may be achieved with a morbidity and mortality in selected patients which is at least equivalent to best conventional surgical practise.[14,25,35]

Selection of cases on the basis of precise anatomical suitability for elective EVAR has been shown to be associated with a much lower rate of re-intervention, morbidity, and procedure-related cost.[12,51,61] Evidence from several studies has shown that the aneurysm morphology is significantly more challenging for endovascular techniques in those assessed for RAAA compared with those undergoing elective EVAR.[38,62,63] Most authors have used established criteria derived from elective EVAR to determine anatomical suitability for EVRAR. However, reported studies reveal substantial variation in the anatomical inclusion and exclusion criteria employed, with anatomical suitability rates ranging from 34% to 100%.[15,16,22,31,38,44] In particular many groups accept inferior proximal neck anatomy which would preclude patients from elective EVAR, suggesting a trend to be more inclusive in these high risk patients.[64] Whilst there is no long term follow-up data available for patients undergoing EVRAR, evidence from elective EVAR would suggest that relaxation of the criteria for anatomical suitability may lead to future problems, such as increased rates of endoleak, graft displacement, complications, re-interventions or the need for open conversion.[51,65]

The majority of centres use contrast-enhanced computed tomographic angiography (CTA) to assess the anatomical suitability of aneurysms for EVRAR.[15,16,22,31,38,44,66–68] Some centres advocate intra-operative calibrated angiography as an effective alternative in order to reduce pre-operative delays.[35,69] However, angiography does not clearly show luminal thrombus, which could adversely affect the ability to obtain a secure seal at the proximal fixation site risking endoleak or late device migration. Generous device oversizing is advocated and can improve the chances of a primary seal.[64,65] However, concerns have been raised in relation to the effect of oversizing on aneurysm neck dilation and late failure.[70] Recent studies suggest CTA assessment can be safely carried out in rupture patients, suggesting any diagnostic delays may not be clinically important.[66,71] Indeed the majority of patients with RAAA who are not operated upon survive for more than two hours after hospital admission and maintain a satisfactory systolic blood pressure greater than 80 mm Hg with minimal fluid resuscitation, which would allow sufficient time for radiological assessment in most specialist centres.[66,71] In Table 5, we summarize current anatomical suitability criteria applied for emergency EVRAR in comparison to established criteria for elective EVAR.[15,16,22,31,38,44,66–68]

Table 5. The Anatomical criteria used for consideration of EVRAR

Criteria	Elective EVAR	Emergency EVRAR	Comment
Neck diameter (max)	28 mm	32 mm	Allow for >10% oversize
Neck length (min)	15 mm	8 mm	Consider proximal fixation
Neck angulation (max)	60°	90°	Consider flexible device
Neck conicity (max)	4 mm/cm	8 mm/cm	Consider oversize
Neck quality	Moderate	Poor	Consider oversize
CIA/EIA diameter (min)	9 mm	6 mm	Consider uni-iliac device or conduit
CIA/EIA diameter (max)	16 mm	22 mm	Consider uni-iliac device
Iliac tortuosity	Moderate	Severe	Consider uni-iliac device or conduit

Data represents for elective EVAR average inclusion criteria for EVAR Trials, and for emergency EVRAR a summary of published contemporary practise. Abbreviations: common iliac artery (CIA); external iliac artery (EIA).

In the haemodynamically unstable patient with RAAA, rapid control of progressive haemorrhage at the aortic rupture site during open surgery is often considered paramount. In the setting of endovascular repair, this control may be achieved by swift endograft placement and deployment, or by placement and inflation of a balloon occlusion device in the aorta proximal to the rupture site.[35,44,72] The reported studies describe the use of both, aorto-uni-iliac (AUI) or aorto-bi-iliac (ABI) devices for EVRAR. Aorto-uni-iliac devices may have the advantage of ease in deployment, and therefore rapid control of haemorrhage, but this approach must be accompanied by a surgical fem-fem crossover bypass graft to provide blood flow to the contralateral lower limb. Aorto-bi-iliac devices, or modular bifurcated grafts, give a better anatomical result but often require more deployment time for cannulation of the contralateral graft limb. However, these are the device of choice for elective EVAR, such that many endovascular specialists are familiar with their capabilities can obtain temporary control by initial proximal deployment of the graft body, delaying release of the contralateral limb until cannulation is imminent or the patient has been stablized.[72] Exposure of the femoral arteries for endograft placement under local anaesthetic is advocated by many and can reduce the haemodynamic instability.[73] Furthermore, a policy of permissive hypotension to reduce bleeding and prevent re-bleeding from the contained aortic rupture site,[13,16] is applied in all studies but with wide variation in the lowest tolerated systolic blood pressures (SBP), with most authors considering an un-assisted SBP greater than 70 mm Hg as indicative of stability).[13,16,40] However, it is notable that even when SBP as low as 50 mm Hg were permitted by some, without increase in end-organ injury, such as visceral ischaemia.[40]

Patient outcomes after EVRAR

For elective aneurysm repair, EVAR is associated with significant reductions in early complications and mortality.[11,50] Paradoxically, this early mortality benefit is not sustained at one-year, were the mortality from EVAR is comparible to open repair but at an increased cost.[11] Furthermore, high-risk patients deemed unfit for elective open surgical repair, faired no better with EVAR than with best medical management in terms of aneurysm-related or all-cause mortality, suggesting that unfitness for open surgery as judged in these studies may be an indicator for reduced life-expectancy.[10] Notable also from the EVAR 2 Trial is that the peri-procedural morality rate of 9% in these high-risk patients was significantly greater than their lower risk counterparts in EVAR 1 Trial.[10,11] However, the risk/benefit analysis is different in patients with RAAA as failure to treat means inevitable death and conventional open surgery continues to carry a very significant risk of mortality, 35% to 70%. Endovascular ruptured aneurysm repair (EVRAR) is less invasive, reduces surgical stress, reduces haemodynamic instability, and can be achieved with a local or loco-regional anaesthesia. The only published RCT showed no benefit for EVRAR in terms of mortality or complications.[16] Indeed mortality in both EVRAR and conventional open groups, in a heavily selected population were unstable patients were excluded, was high at 53% compared to many contemporary reports.[16] In the non-randomised studies EVRAR was associated with a low mortality rate, average 17% (range 0–45), compared in some studies to contemporary or historical control groups undergoing open repair, average 34% (range 0–70), for patients with ruptured abdominal aortic aneurysm. Furthermore, this mortality benefit mirrors a procedural-related reduction in blood loss, transfusion requirements, and length of ICU stay (Tables 2–4). These perceived benefits are generally attributed to a reduction in the physiological insult to the patients, as EVRAR obviates the need for laparotomy, exposure and handling of abdominal contents, and aorto-iliac dissection and clamping. In the majority of the studies EVRAR was conducted under general anaesthetic, although it is clear that even AUI device placement with surgical femoro-femoral bypass graft can be achieved under local anaesthetic regimes.[73] However, results from selected populations in these non-randomised studies must be interpreted with caution.

Implications for vascular services

A distinct learning curve effect is noted in the studies involving EVRAR, which especially is important as all of these arise from centres with already considerable experience with elective endovascular aneurysm procedures.[14,25,35,44] The more recent studies show a greater reduction in procedure times, mortality and complication rates.[18,22,45] As has been seen with elective EVAR practice, advancements in stent-graft design and endovascular techniques have lead to improved outcomes.[51] Re-intervention rates also appear comparable with those seen with elective endovascular repair.[51,74] However, long-term data are needed in order to truly assess if EVRAR is a durable treatment in relation to endoleak, stent-graft integrity, and late rupture risk. It is clear that the introduction of an EVRAR service has substantial cost implications, in terms of staff, fixed resources and procedure-associated equipment. In order to provide a comprehensive 24-hour service the necessary team of surgeons, radiologists, anaesthetists, radiographers, nurses and technicians need to be available at all times.[15] This may impact on the transferability of this technique beyond specialist centres. These logistical deficiencies were highlighted by the low recruitment rate to the RCT even from a very experienced endovascular centre.[16] Whilst, most units had a wide range of stent-graft stock available to cope with the variable anatomy encountered, the majority of patient can be treated with a small range of devices made available by satisfactory arrangement with a commercial partner. Surveillance protocols in respect to imaging after EVRAR may be similar to elective practice, although the frequency of medium and late complications is as yet unknown and may require a high rate of re-intervention by endovascular or open means, in relation to endoleak, device migration, strut fracture, limb occlusion or late rupture.[15,70,75]

Study limitations

In the absence of high-quality randomised controlled trials, we are unable to fully evaluate the role of emergency endovascular ruptured abdominal aortic aneurysm repair (EVRAR). Early results from specialist centres show this technique is feasible. Data suggesting reduced morbidity and mortality in selected patients must be interpreted with caution due to the lack of randomisation in these studies. Further trials to evaluate the role of EVRAR in the treatment of RAAA are required. These trials should be methodologically adequate in terms of sample sizes, treatment standardization and duration of follow up. Clinically-relevant outcomes such as rate of major complications, open-conversion, aneurysm exclusion, endoleak, rupture, and mortality should be assessed. However, accumulating evidence from non-randomised studies, which show significant reductions in mortality in selected patients deemed suitable for endovascular repair, may raise ethical concerns in relation to informed consent and randomisation of these patients to open repair. Large prospective studies are required to validate the acceptable anatomical criteria for EVRAR in RAAA. Furthermore, longitudinal studies are required to assess the long-term durability of this form of treatment in terms of re-intervention rate, open-conversion rate, and rupture-free survival.

Conclusions

Accumulating published data suggests that endovascular ruptured abdominal aortic aneurysm repair (EVRAR) is feasible in selected patients in institutions with experience of endovascular techniques for the treatment of ruptured abdominal aortic aneurysm. Furthermore, in those selected patients EVRAR may also be accompanied by reductions in blood loss, Intensive Care Unit (ICU) stay, and mortality. However, a significant proportion of patients with ruptured abdominal aortic aneurysm remain anatomically unsuitable for contemporary endovascular repair, and whilst relaxation of exclusion criteria may make EVRAR feasible, this is likely to increase device and aneurysm related complications.

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